

WHAT IS CLAIMED IS:

1 1. A pattern-center determination apparatus for
2 determining a pattern center of a fingerprint-like pattern,
3 which is formed with a number of pattern curves, said
4 apparatus comprising:

5 an auxiliary-line generation section for generating
6 two or more auxiliary lines extending continuously from an
7 outer circumference side one of the pattern curves of the
8 fingerprint-like pattern toward an inner circumference side
9 one of the pattern curves so that each of the two or more
10 auxiliary lines intersects each of the pattern curves
11 perpendicularly or substantially perpendicularly; and

12 a pattern-center determination section for
13 determining the pattern center based on one or more
14 intersecting points of the two or more auxiliary lines
15 generated by said auxiliary-line generation section.

1 2. A pattern-center determination apparatus as
2 claimed in claim 1, wherein said auxiliary-line generation
3 section is operable to generate two auxiliary lines, and said
4 pattern-center determination section is operable to
5 determine an intersecting point of the two auxiliary lines
6 generated by said auxiliary-line generation section as the
7 pattern center.

1 3. A pattern-center determination apparatus as

2 claimed in claim 1, wherein said pattern-center
3 determination section includes an auxiliary-line-
4 intersecting-point calculation section for calculating one
5 or more intersecting points of the two or more auxiliary lines
6 generated by said auxiliary-line generation section, and a
7 most-crowded-point calculation section for calculating a
8 most crowded point, at which the intersecting points
9 calculated by said auxiliary-line-intersecting-point
10 calculation section are most crowded, so as to determine the
11 calculated most crowded point as the pattern center.

1 4. A pattern-center determination apparatus as
2 claimed in claim 1, wherein said auxiliary-line generation
3 section includes:
4 a start-point setting section for setting an arbitrary
5 point of the fingerprint-like pattern as a start point;
6 a reference-circle generation section for generating
7 a reference circle of a predetermined radius centered at the
8 start point set by said start-point setting section;
9 a reference-circle-intersecting-point calculation
10 section for calculating intersecting points of the reference
11 circle generated by said reference-circle generation section
12 and the pattern curves of the fingerprint-like pattern;
13 an intersecting-point extraction section for
14 extracting those two of the intersecting points calculated
15 by said reference-circle-intersecting-point calculation
16 section which satisfy a predetermined condition;

17 an end-point calculation section for calculating a
18 middle point of the two intersecting points extracted by said
19 intersecting-point extraction section as an end point; and
20 a line-segment generation section for generating a
21 line segment interconnecting the start point set by said
22 start-point setting section and the end point calculated by
23 said end-point calculation section;
24 wherein said start-point setting section is operable
25 to set the end point as a new start point so that said
26 reference-circle generation section, said reference-
27 circle-intersecting-point calculation section, said
28 intersecting-point extraction section, said end-point
29 calculation section and said line-segment generation section
30 repeatedly generate a new line segment, thereby generating
31 the auxiliary line as a number of successive line segments.

1 5. A pattern-center determination apparatus as
2 claimed in claim 2, wherein said auxiliary-line generation
3 section includes:

4 a start-point setting section for setting an arbitrary
5 point of the fingerprint-like pattern as a start point;

6 a reference-circle generation section for generating
7 a reference circle of a predetermined radius centered at the
8 start point set by said start-point setting section;

9 a reference-circle-intersecting-point calculation
10 section for calculating intersecting points of the reference
11 circle generated by said reference-circle generation section

12 and the pattern curves of the fingerprint-like pattern;
13 an intersecting-point extraction section for
14 extracting those two of the intersecting points calculated
15 by said reference-circle-intersecting-point calculation
16 section which satisfy a predetermined condition;
17 an end-point calculation section for calculating a
18 middle point of the two intersecting points extracted by said
19 intersecting-point extraction section as an end point; and
20 a line-segment generation section for generating a
21 line segment interconnecting the start point set by said
22 start-point setting section and the end point calculated by
23 said end-point calculation section;
24 wherein said start-point setting section is operable
25 to set the end point as a new start point so that said
26 reference-circle generation section, said reference-
27 circle-intersecting-point calculation section, said
28 intersecting-point extraction section, said end-point
29 calculation section and said line-segment generation section
30 repeatedly generate a new line segment, thereby generating
31 the auxiliary line as a number of successive line segments.

1 6. A pattern-center determination apparatus as
2 claimed in claim 3, wherein said auxiliary-line generation
3 section includes:

4 a start-point setting section for setting an arbitrary
5 point of the fingerprint-like pattern as a start point;
6 a reference-circle generation section for generating

7 a reference circle of a predetermined radius centered at the
8 start point set by said start-point setting section;
9 a reference-circle-intersecting-point calculation
10 section for calculating intersecting points of the reference
11 circle generated by said reference-circle generation section
12 and the pattern curves of the fingerprint-like pattern;
13 an intersecting-point extraction section for
14 extracting those two of the intersecting points calculated
15 by said reference-circle-intersecting-point calculation
16 section which satisfy a predetermined condition;
17 an end-point calculation section for calculating a
18 middle point of the two intersecting points extracted by said
19 intersecting-point extraction section as an end point; and
20 a line-segment generation section for generating a
21 line segment interconnecting the start point set by said
22 start-point setting section and the end point calculated by
23 said end-point calculation section;
24 wherein said start-point setting section is operable
25 to set the end point as a new start point so that said
26 reference-circle generation section, said reference-
27 circle-intersecting-point calculation section, said
28 intersecting-point extraction section, said end-point
29 calculation section and said line-segment generation section
30 repeatedly generate a new line segment, thereby generating
31 the auxiliary line as a number of successive line segments.

1 7. A pattern-center determination apparatus as

2 claimed in claim 1, wherein said auxiliary-line generation
3 section includes:

4 a first-auxiliary-point setting section for setting
5 two arbitrary points on an arbitrary one of pattern curves
6 which form the fingerprint-like pattern as two first
7 auxiliary points;

8 a start-point calculation section for calculating a
9 middle point of the two first auxiliary points set by said
10 first-auxiliary-point setting section as a start point;

11 an auxiliary-line-segment generation section for
12 generating an auxiliary-line segment interconnecting the two
13 first auxiliary points set by said first-auxiliary-point
14 setting section;

15 a perpendicular-bisector generation section for
16 generating a perpendicular bisector to the auxiliary-line
17 segment generated by said auxiliary-line-segment generation
18 section;

19 a perpendicular-bisector-intersecting-point
20 calculation section for calculating that one of intersecting
21 points of the perpendicular bisector generated by said
22 perpendicular-bisector generation section and the pattern
23 curves of the fingerprint-like pattern which is present on
24 a particular side with respect to the start point and
25 positioned nearest to the start point;

26 a node calculation section for calculating a point on
27 the perpendicular bisector spaced by a predetermined
28 distance toward the particular side from the intersecting

29 point calculated by said perpendicular-bisector-
30 intersecting-point calculation section as a node;
31 a straight-line generation section for generating a
32 straight line which passes the node calculated by said node
33 calculation section and intersects orthogonally with the
34 perpendicular bisector;
35 a second-auxiliary-point calculation section for
36 calculating those two of intersecting points of the straight
37 line generated by said straight-line generation section and
38 the pattern curves of the fingerprint-like pattern which are
39 on the opposite sides of the node and are positioned nearest
40 to the node as second auxiliary points;
41 an end-point calculation section for calculating a
42 middle point of the two second auxiliary points calculated
43 by said second-auxiliary-point calculation section as an end
44 point;
45 a first-line-segment generation section for
46 generating a first line segment interconnecting the start
47 point calculated by said start-point calculation section and
48 the node calculated by said node calculation section; and
49 a second-line-segment generation section for
50 generating a second line segment interconnecting the node
51 calculated by said node calculation section and the end point
52 calculated by said end-point calculation section;
53 wherein said first-auxiliary-point setting section is
54 operable to set the two second auxiliary points as new first
55 auxiliary points so that said start-point calculation

56 section, said auxiliary-line-segment generation section,
57 said perpendicular-bisector generation section, said
58 perpendicular-bisector-intersecting-point calculation
59 section, said node calculation section, said straight-line
60 generation section, said second-auxiliary-point calculation
61 section, said end-point calculation section, said first-
62 line-segment generation section and said second-line-
63 segment generation section repeatedly generate new first and
64 second line segments, thereby generating the auxiliary line
65 as a number of alternately successive first and second line
66 segments.

1 8. A pattern-center determination apparatus as
2 claimed in claim 2, wherein said auxiliary-line generation
3 section includes:

4 a first-auxiliary-point setting section for setting
5 two arbitrary points on an arbitrary one of pattern curves
6 which form the fingerprint-like pattern as two first
7 auxiliary points;

8 a start-point calculation section for calculating a
9 middle point of the two first auxiliary points set by said
10 first-auxiliary-point setting section as a start point;

11 an auxiliary-line-segment generation section for
12 generating an auxiliary-line segment interconnecting the two
13 first auxiliary points set by said first-auxiliary-point
14 setting section;

15 a perpendicular-bisector generation section for

16 generating a perpendicular bisector to the auxiliary-line
17 segment generated by said auxiliary-line-segment generation
18 section;

19 a perpendicular-bisector-intersecting-point
20 calculation section for calculating that one of intersecting
21 points of the perpendicular bisector generated by said
22 perpendicular-bisector generation section and the pattern
23 curves of the fingerprint-like pattern which is present on
24 a particular side with respect to the start point and
25 positioned nearest to the start point;

26 a node calculation section for calculating a point on
27 the perpendicular bisector spaced by a predetermined
28 distance toward the particular side from the intersecting
29 point calculated by said perpendicular-bisector-
30 intersecting-point calculation section as a node;

31 a straight-line generation section for generating a
32 straight line which passes the node calculated by said node
33 calculation section and intersects orthogonally with the
34 perpendicular bisector;

35 a second-auxiliary-point calculation section for
36 calculating those two of intersecting points of the straight
37 line generated by said straight-line generation section and
38 the pattern curves of the fingerprint-like pattern which are
39 on the opposite sides of the node and are positioned nearest
40 to the node as second auxiliary points;

41 an end-point calculation section for calculating a
42 middle point of the two second auxiliary points calculated

43 by said second-auxiliary-point calculation section as an end
44 point;

45 a first-line-segment generation section for
46 generating a first line segment interconnecting the start
47 point calculated by said start-point calculation section and
48 the node calculated by said node calculation section; and

49 a second-line-segment generation section for
50 generating a second line segment interconnecting the node
51 calculated by said node calculation section and the end point
52 calculated by said end-point calculation section;

53 wherein said first-auxiliary-point setting section is
54 operable to set the two second auxiliary points as new first
55 auxiliary points so that said start-point calculation
56 section, said auxiliary-line-segment generation section,
57 said perpendicular-bisector generation section, said
58 perpendicular-bisector-intersecting-point calculation
59 section, said node calculation section, said straight-line
60 generation section, said second-auxiliary-point calculation
61 section, said end-point calculation section, said first-
62 line-segment generation section and said second-line-
63 segment generation section repeatedly generate new first and
64 second line segments, thereby generating the auxiliary line
65 as a number of alternately successive first and second line
66 segments.

1 9. A pattern-center determination apparatus as
2 claimed in claim 3, wherein said auxiliary-line generation

3 section includes:

4 a first-auxiliary-point setting section for setting
5 two arbitrary points on an arbitrary one of pattern curves
6 which form the fingerprint-like pattern as two first
7 auxiliary points;

8 a start-point calculation section for calculating a
9 middle point of the two first auxiliary points set by said
10 first-auxiliary-point setting section as a start point;

11 an auxiliary-line-segment generation section for
12 generating an auxiliary-line segment interconnecting the two
13 first auxiliary points set by said first-auxiliary-point
14 setting section;

15 a perpendicular-bisector generation section for
16 generating a perpendicular bisector to the auxiliary-line
17 segment generated by said auxiliary-line-segment generation
18 section;

19 a perpendicular-bisector-intersecting-point
20 calculation section for calculating that one of intersecting
21 points of the perpendicular bisector generated by said
22 perpendicular-bisector generation section and the pattern
23 curves of the fingerprint-like pattern which is present on
24 a particular side with respect to the start point and
25 positioned nearest to the start point;

26 a node calculation section for calculating a point on
27 the perpendicular bisector spaced by a predetermined
28 distance toward the particular side from the intersecting
29 point calculated by said perpendicular-bisector-

30 intersecting-point calculation section as a node;

31 a straight-line generation section for generating a
32 straight line which passes the node calculated by said node
33 calculation section and intersects orthogonally with the
34 perpendicular bisector;

35 a second-auxiliary-point calculation section for
36 calculating those two of intersecting points of the straight
37 line generated by said straight-line generation section and
38 the pattern curves of the fingerprint-like pattern which are
39 on the opposite sides of the node and are positioned nearest
40 to the node as second auxiliary points;

41 an end-point calculation section for calculating a
42 middle point of the two second auxiliary points calculated
43 by said second-auxiliary-point calculation section as an end
44 point;

45 a first-line-segment generation section for
46 generating a first line segment interconnecting the start
47 point calculated by said start-point calculation section and
48 the node calculated by said node calculation section; and

49 a second-line-segment generation section for
50 generating a second line segment interconnecting the node
51 calculated by said node calculation section and the end point
52 calculated by said end-point calculation section;

53 wherein said first-auxiliary-point setting section is
54 operable to set the two second auxiliary points as new first
55 auxiliary points so that said start-point calculation
56 section, said auxiliary-line-segment generation section,

57 said perpendicular-bisector generation section, said
58 perpendicular-bisector-intersecting-point calculation
59 section, said node calculation section, said straight-line
60 generation section, said second-auxiliary-point calculation
61 section, said end-point calculation section, said first-
62 line-segment generation section and said second-line-
63 segment generation section repeatedly generate new first and
64 second line segments, thereby generating the auxiliary line
65 as a number of alternately successive first and second line
66 segments.

1 10. A pattern-center determination apparatus as
2 claimed in claim 1, wherein said auxiliary-line generation
3 section includes:

4 a start-point setting section for setting an arbitrary
5 point on an arbitrary one of the pattern curves of the
6 fingerprint-like pattern as a start point;

7 an auxiliary-point calculation section for
8 calculating two points positioned on the pattern curve on
9 which the start point set by said start-point setting section
10 is present and spaced by a predetermined distance from the
11 start point to the opposite sides along the pattern curve
12 as auxiliary points;

13 an auxiliary-line-segment generation section for
14 generating an auxiliary-line segment interconnecting the two
15 auxiliary points calculated by said auxiliary-point
16 calculation section;

17 a straight-line generation section for generating a
18 straight line which passes the start point set by said
19 start-point setting section and intersects orthogonally with
20 the auxiliary-line segment generated by said auxiliary-
21 line-segment generation section;

22 an end-point calculation section for calculating that
23 one of intersecting points of the straight line generated
24 by said straight-line generation section and the pattern
25 curves of the fingerprint-like pattern which is positioned
26 on a particular side with respect to the start point and
27 nearest to the start point as an end point; and

28 a line-segment generation section for generating a
29 line segment interconnecting the start point set by said
30 start-point setting section and the end point calculated by
31 said end-point calculation section;

32 wherein said start-point setting section is operable
33 to set the end point as a new start point so that said
34 auxiliary-point calculation section, said auxiliary-
35 line-segment generation section, said straight-line
36 generation section, said end-point calculation section and
37 said line-segment generation section repeatedly generate a
38 new line segment, thereby generating the auxiliary line as
39 a number of successive line segments.

1 11. A pattern-center determination apparatus as
2 claimed in claim 2, wherein said auxiliary-line generation
3 section includes:

4 a start-point setting section for setting an arbitrary
5 point on an arbitrary one of the pattern curves of the
6 fingerprint-like pattern as a start point;
7 an auxiliary-point calculation section for
8 calculating two points positioned on the pattern curve on
9 which the start point set by said start-point setting section
10 is present and spaced by a predetermined distance from the
11 start point to the opposite sides along the pattern curve
12 as auxiliary points;
13 an auxiliary-line-segment generation section for
14 generating an auxiliary-line segment interconnecting the two
15 auxiliary points calculated by said auxiliary-point
16 calculation section;
17 a straight-line generation section for generating a
18 straight line which passes the start point set by said
19 start-point setting section and intersects orthogonally with
20 the auxiliary-line segment generated by said auxiliary-
21 line-segment generation section;
22 an end-point calculation section for calculating that
23 one of intersecting points of the straight line generated
24 by said straight-line generation section and the pattern
25 curves of the fingerprint-like pattern which is positioned
26 on a particular side with respect to the start point and
27 nearest to the start point as an end point; and
28 a line-segment generation section for generating a
29 line segment interconnecting the start point set by said
30 start-point setting section and the end point calculated by

31 said end-point calculation section;
32 wherein said start-point setting section is operable
33 to set the end point as a new start point so that said
34 auxiliary-point calculation section, said auxiliary-
35 line-segment generation section, said straight-line
36 generation section, said end-point calculation section and
37 said line-segment generation section repeatedly generate a
38 new line segment, thereby generating the auxiliary line as
39 a number of successive line segments.

1 12. A pattern-center determination apparatus as
2 claimed in claim 3, wherein said auxiliary-line generation
3 section includes:

4 a start-point setting section for setting an arbitrary
5 point on an arbitrary one of the pattern curves of the
6 fingerprint-like pattern as a start point;

7 an auxiliary-point calculation section for
8 calculating two points positioned on the pattern curve on
9 which the start point set by said start-point setting section
10 is present and spaced by a predetermined distance from the
11 start point to the opposite sides along the pattern curve
12 as auxiliary points;

13 an auxiliary-line-segment generation section for
14 generating an auxiliary-line segment interconnecting the two
15 auxiliary points calculated by said auxiliary-point
16 calculation section;

17 a straight-line generation section for generating a

18 straight line which passes the start point set by said
19 start-point setting section and intersects orthogonally with
20 the auxiliary-line segment generated by said auxiliary-
21 line-segment generation section;

22 an end-point calculation section for calculating that
23 one of intersecting points of the straight line generated
24 by said straight-line generation section and the pattern
25 curves of the fingerprint-like pattern which is positioned
26 on a particular side with respect to the start point and
27 nearest to the start point as an end point; and

28 a line-segment generation section for generating a
29 line segment interconnecting the start point set by said
30 start-point setting section and the end point calculated by
31 said end-point calculation section;

32 wherein said start-point setting section is operable
33 to set the end point as a new start point so that said
34 auxiliary-point calculation section, said auxiliary-
35 line-segment generation section, said straight-line
36 generation section, said end-point calculation section and
37 said line-segment generation section repeatedly generate a
38 new line segment, thereby generating the auxiliary line as
39 a number of successive line segments.

1 13. A pattern-center determination method for
2 determining a pattern center of a fingerprint-like pattern,
3 which is formed with a number of pattern curves, said method
4 comprising the steps of:

5 generating two or more auxiliary lines extending
6 continuously from an outer circumference side one of the
7 pattern curves of the fingerprint-like pattern toward an
8 inner circumference side one of the pattern curves so that
9 each of the two or more auxiliary lines intersects each of
10 the pattern curves perpendicularly or substantially
11 perpendicularly; and
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines.

1 14. A computer-readable recording medium on which
2 a pattern-center determination program is recorded for use
3 with a computer, said program being for determining a pattern
4 center of a fingerprint-like pattern, which is formed with
5 a number of pattern curves, and instructing the computer to
6 function as:

7 an auxiliary-line generation section for generating
8 two or more auxiliary lines extending continuously from an
9 outer circumference side one of the pattern curves of the
10 fingerprint-like pattern toward an inner circumference side
11 one of the pattern curves so that each of the two or more
12 auxiliary lines intersects each of the pattern curves
13 perpendicularly or substantially perpendicularly; and

14 a pattern-center determination section for
15 determining the pattern center based on one or more
16 intersecting points of the two or more auxiliary lines
17 generated by said auxiliary-line generation section.

1 15. A pattern-orientation determination apparatus
2 for determining a pattern orientation of a fingerprint-like
3 pattern, which is formed with a number of pattern curves,
4 said apparatus comprising:
5 a pattern-center determination section for
6 determining a pattern center of the fingerprint-like
7 pattern;
8 a reference-circle generation section for generating
9 a reference circle of a predetermined radius centered at the
10 pattern center determined by said pattern-center
11 determination section;
12 a reference-circle-intersecting-point calculation
13 section for calculating intersecting points of the reference
14 circle generated by said reference-circle generation section
15 and the pattern curves of the fingerprint-like pattern;
16 a reference-point determination section for
17 determining a reference point for the pattern orientation
18 based on a relationship between directions of the reference
19 circle and directions of the pattern curves at the
20 intersecting points calculated by said reference-circle-
21 intersecting-point calculation section; and
22 a pattern-orientation determination section for
23 determining the pattern orientation based on the pattern
24 center determined by said pattern-center determination
25 section and the reference point determined by said
26 reference-point determination section.

1 16. A pattern-orientation determination apparatus
2 as claimed in claim 15, wherein said reference-point
3 determination section includes:

4 an intersecting-point extraction section for
5 extracting those two of the intersecting points calculated
6 by said reference-circle-intersecting-point calculation
7 section which satisfy a predetermined condition; and

8 a reference-point calculation section for calculating
9 a middle point of the two intersecting points extracted by
10 said intersecting-point extraction section as the reference
11 point.

1 17. A pattern-orientation determination apparatus
2 as claimed in claim 15, wherein said pattern-orientation
3 determination section includes a rectification section for
4 rectifying the position of the pattern center based on those
5 of the pattern curves which are present in the proximity of
6 the pattern center, and said pattern-orientation
7 determination section is operable to determine the direction
8 of a reference straight line which passes the position of
9 the pattern center rectified by said rectification section
10 and the reference point as the pattern orientation.

1 18. A pattern-orientation determination apparatus
2 as claimed in claim 16, wherein said pattern-orientation
3 determination section includes a rectification section for

4 rectifying the position of the pattern center based on those
5 of the pattern curves which are present in the proximity of
6 the pattern center, and said pattern-orientation
7 determination section is operable to determine the direction
8 of a reference straight line which passes the position of
9 the pattern center rectified by said rectification section
10 and the reference point as the pattern orientation.

1 19. A pattern-orientation determination apparatus
2 according to claim 15, wherein said pattern-orientation
3 determination section is operable to determine the direction
4 of a reference straight line which passes the pattern center
5 and the reference point as the pattern orientation.

1 20. A pattern-orientation determination apparatus
2 according to claim 16, wherein said pattern-orientation
3 determination section is operable to determine the direction
4 of a reference straight line which passes the pattern center
5 and the reference point as the pattern orientation.

1 21. A pattern-orientation determination apparatus
2 according to claim 15, wherein said pattern-center
3 determination section includes:
4 an auxiliary-line generation section for generating
5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side

8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines
14 generated by said auxiliary-line generation section.

1 22. A pattern-orientation determination apparatus
2 according to claim 16, wherein said pattern-center
3 determination section includes:

4 an auxiliary-line generation section for generating
5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side
8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines
14 generated by said auxiliary-line generation section.

1 23. A pattern-orientation determination apparatus
2 according to claim 17, wherein said pattern-center
3 determination section includes:

4 an auxiliary-line generation section for generating

5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side
8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines
14 generated by said auxiliary-line generation section.

1 24. A pattern-orientation determination apparatus
2 according to claim 18, wherein said pattern-center
3 determination section includes:

4 an auxiliary-line generation section for generating
5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side
8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines
14 generated by said auxiliary-line generation section.

1 25. A pattern-orientation determination apparatus

2 according to claim 19, wherein said pattern-center
3 determination section includes:

4 an auxiliary-line generation section for generating
5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side
8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines
14 generated by said auxiliary-line generation section.

1 26. A pattern-orientation determination apparatus
2 according to claim 20, wherein said pattern-center
3 determination section includes:

4 an auxiliary-line generation section for generating
5 two or more auxiliary lines extending continuously from an
6 outer circumference side one of the pattern curves of the
7 fingerprint-like pattern toward an inner circumference side
8 one of the pattern curves so that each of the auxiliary lines
9 intersects each of the pattern curves perpendicularly or
10 substantially perpendicularly; and

11 a pattern-center determination section for
12 determining the pattern center based on one or more
13 intersecting points of the two or more auxiliary lines

14 generated by said auxiliary-line generation section.

1 27. A pattern-orientation determination method for
2 determining a pattern orientation of a fingerprint-like
3 pattern, which is formed with a number of pattern curves,
4 said method comprising the steps of:

5 determining a pattern center of the fingerprint-like
6 pattern;

7 generating a reference circle of a predetermined
8 radius centered at the pattern center;

9 calculating intersecting points of the reference
10 circle and the pattern curves of the fingerprint-like
11 pattern;

12 determining a reference point for the pattern
13 orientation based on a relationship between directions of
14 the reference circle and directions of the pattern curves
15 at the calculated intersecting points; and

16 determining the pattern orientation based on the
17 pattern center and the reference point.

1 28. A computer-readable recording medium on which
2 a pattern-orientation determination program is recorded for
3 use with a computer, said program being for determining a
4 pattern orientation of a fingerprint-like pattern, which is
5 formed with a number of pattern curves, and instructing the
6 computer to function as:

7 a pattern-center determination section for

8 determining a pattern center of the fingerprint-like
9 pattern;
10 a reference-circle generation section for generating
11 a reference circle of a predetermined radius centered at the
12 pattern center determined by said pattern-center
13 determination section;
14 a reference-circle-intersecting-point calculation
15 section for calculating intersecting points of the reference
16 circle generated by said reference-circle generation section
17 and the pattern curves of the fingerprint-like pattern;
18 a reference-point determination section for
19 determining a reference point for the pattern orientation
20 based on a relationship between directions of the reference
21 circle and directions of the pattern curves at the
22 intersecting points calculated by said reference-circle-
23 intersecting-point calculation section; and
24 a pattern-orientation determination section for
25 determining the pattern orientation based on the pattern
26 center determined by said pattern-center determination
27 section and the reference point determined by said
28 reference-point determination section.

1 29. A pattern alignment apparatus for aligning two
2 fingerprint-like patterns, each of which is formed with a
3 number of pattern curves, said apparatus comprising:
4 an alignment-reference determination section for
5 determining one or more alignment references for each of the

6 fingerprint-like patterns; and
7 an alignment section for aligning the two
8 fingerprint-like patterns so that the alignment references
9 of the two fingerprint-like patterns determined by said
10 alignment-reference determination section coincide with
11 each other;
12 said alignment-reference determination section
13 including a pattern-center determination section for
14 determining a pattern center of each of the fingerprint-
15 like patterns as one of the alignment references, said
16 pattern-center determination section having
17 an auxiliary-line generation section for
18 generating two or more auxiliary lines extending
19 continuously from an outer circumference side one of the
20 pattern curves of each said fingerprint-like pattern toward
21 an inner circumference side one of the pattern curves so that
22 each of the auxiliary lines intersects each of the pattern
23 curves perpendicularly or substantially perpendicularly,
24 and
25 a pattern-center determination section for
26 determining the pattern center based on one or more
27 intersecting points of the two or more auxiliary lines
28 generated by said auxiliary-line generation section.

1 30. A pattern alignment apparatus as claimed in
2 claim 29, wherein said alignment-reference determination
3 section further includes a pattern-orientation

4 determination section for determining a pattern orientation
5 of each of the fingerprint-like patterns as one of the
6 alignment references, said pattern-orientation
7 determination section having:

8 a reference-circle generation section for generating
9 a reference circle of a predetermined radius centered at the
10 pattern center determined by said pattern-center
11 determination section;

12 a reference-circle-intersecting-point calculation
13 section for calculating intersecting points of the reference
14 circle generated by said reference-circle generation section
15 and the pattern curves of the fingerprint-like pattern;

16 a reference-point determination section for
17 determining a reference point for the pattern orientation
18 based on a relationship between directions of the reference
19 circle and directions of the pattern curves at the
20 intersecting points calculated by said reference-circle-
21 intersecting-point calculation section; and

22 a pattern-orientation determination section for
23 determining the pattern orientation based on the pattern
24 center determined by said pattern-center determination
25 section and the reference point determined by said
26 reference-point determination section.

1 31. A pattern alignment apparatus for aligning two
2 fingerprint-like patterns, each of which is formed with a
3 number of pattern curves, said apparatus comprising:

4 an alignment-reference determination section for
5 determining one or more alignment references for each of the
6 fingerprint-like patterns; and

7 an alignment section for aligning the two
8 fingerprint-like patterns so that the alignment references
9 of the two fingerprint-like patterns determined by said
10 alignment-reference determination section coincide with
11 each other;

12 said alignment-reference determination section
13 including a pattern-orientation determination section for
14 determining a pattern orientation of each of the
15 fingerprint-like patterns as one of the alignment references,
16 said pattern-orientation determination section having

17 a pattern-center determination section for
18 determining a pattern center of each said fingerprint-like
19 patterns as the alignment reference,

20 a reference-circle generation section for
21 generating a reference circle of a predetermined radius
22 centered at the pattern center determined by said
23 pattern-center determination section,

24 a reference-circle-intersecting-point
25 calculation section for calculating intersecting points of
26 the reference circle generated by said reference-circle
27 generation section and the pattern curves of each said
28 fingerprint-like pattern,

29 a reference-point determination section for
30 determining a reference point for the pattern orientation

31 based on a relationship between directions of the reference
32 circle and directions of the pattern curves at the
33 intersecting points calculated by said reference-circle-
34 intersecting-point calculation section, and
35 a pattern-orientation determination section for
36 determining the pattern orientation based on the pattern
37 center determined by said pattern-center determination
38 section and the reference point determined by said
39 reference-point determination section.

1 32. A pattern alignment apparatus as claimed in
2 claim 29, further comprising:

3 a minutia extraction section for extracting a group
4 of minutiae from each of the two fingerprint-like patterns;

5 a collation section for collating the two group of
6 minutiae extracted from the two fingerprint-like patterns
7 by said minutia extraction section based on the alignment
8 by said alignment section;

9 an adjustment-shift calculation section for
10 calculating an adjustment shift of at least one of the two
11 fingerprint-like patterns based on a result of the collation
12 by said collation section so that the alignment of the two
13 fingerprint-like patterns is improved; and

14 a alignment-result adjustment section for shifting at
15 least one of the two fingerprint-like patterns by the
16 adjustment shift calculated by said adjustment-shift
17 calculation section so as to adjust a result of the alignment

18 by said alignment section.

1 33. A pattern alignment apparatus as claimed in
2 claim 30, further comprising:

3 a minutia extraction section for extracting a group
4 of minutiae from each of the two fingerprint-like patterns;

5 a collation section for collating the two group of
6 minutiae extracted from the two fingerprint-like patterns
7 by said minutia extraction section based on the alignment
8 by said alignment section;

9 an adjustment-shift calculation section for
10 calculating an adjustment shift of at least one of the two
11 fingerprint-like patterns based on a result of the collation
12 by said collation section so that the alignment of the two
13 fingerprint-like patterns is improved; and

14 a alignment-result adjustment section for shifting at
15 least one of the two fingerprint-like patterns by the
16 adjustment shift calculated by said adjustment-shift
17 calculation section so as to adjust a result of the alignment
18 by said alignment section.

1 34. A pattern alignment apparatus as claimed in
2 claim 31, further comprising:

3 a minutia extraction section for extracting a group
4 of minutiae from each of the fingerprint-like patterns;

5 a collation section for collating the two group of
6 minutiae extracted from the two fingerprint-like patterns

7 by said minutia extraction section based on the alignment
8 by said alignment section;

9 an adjustment-shift calculation section for
10 calculating an adjustment shift of at least one of the two
11 fingerprint-like patterns based on a result of the collation
12 by said collation section so that the alignment of the two
13 fingerprint-like patterns is improved; and

14 a alignment-result adjustment section for shifting at
15 least one of the two fingerprint-like patterns by the
16 adjustment shift calculated by said adjustment-shift
17 calculation section so as to adjust a result of the alignment
18 by said alignment section.

1 35. A pattern alignment apparatus as claimed in
2 claim 32, wherein the adjustment shift is at least one of
3 a rotation angle by which one of the two fingerprint-like
4 patterns is to be rotated around a predetermined point with
5 respect to the other of the two fingerprint-like patterns
6 and a shift by which one of the two fingerprint-like patterns
7 is to be parallelly shifted with respect to the other of the
8 two fingerprint-like patterns.

1 36. A pattern alignment apparatus as claimed in
2 claim 33, wherein the adjustment shift is at least one of
3 a rotation angle by which one of the two fingerprint-like
4 patterns is to be rotated around a predetermined point with
5 respect to the other of the two fingerprint-like patterns

6 and a shift by which one of the two fingerprint-like patterns
7 is to be parallelly shifted with respect to the other of the
8 two fingerprint-like patterns.

1 37. A pattern alignment apparatus as claimed in
2 claim 34, wherein the adjustment shift is at least one of
3 a rotation angle by which one of the two fingerprint-like
4 patterns is to be rotated around a predetermined point with
5 respect to the other of the two fingerprint-like patterns
6 and a shift by which one of the two fingerprint-like patterns
7 is to be parallelly shifted with respect to the other of the
8 two fingerprint-like patterns.

1 38. A pattern verification apparatus for verifying
2 a group of object minutiae for verification extracted from
3 an object fingerprint-like pattern for verification with a
4 group of registered minutiae extracted in advance from a
5 registered fingerprint-like pattern, each of the object
6 fingerprint-like pattern and the registered fingerprint-
7 like pattern being formed with the number of pattern curves,
8 said apparatus comprising:

9 a pattern inputting section for inputting the object
10 fingerprint-like pattern;

11 an alignment-reference determination section for
12 determining one or more alignment references of the object
13 fingerprint-like pattern inputted by said pattern inputting
14 section;

15 a minutia extraction section for extracting the group
16 of object minutiae from the object fingerprint-like pattern
17 inputted by said pattern inputting section;

18 a registration-data obtaining section for obtaining
19 registration data regarding the registered fingerprint-like
20 pattern, said registration data including the group of
21 registered minutiae and one or more alignment references of
22 the registered fingerprint-like pattern;

23 an alignment section for aligning the object
24 fingerprint-like pattern or the group of object minutiae and
25 the group of registered minutiae so that the alignment
26 references of the object fingerprint-like pattern determined
27 by said alignment-reference determination section and the
28 alignment references of the registered fingerprint-like
29 pattern obtained by said registration-data obtaining section
30 coincide with each other; and

31 a verification section for verifying the group of
32 object minutiae with the group of registered minutiae based
33 on the alignment by said alignment section;

34 said alignment-reference determination section
35 including a pattern-center determination section for
36 determining a pattern center of the object fingerprint-like
37 pattern as one of the alignment references of the object
38 fingerprint-like pattern,

39 the alignment references of the registered
40 fingerprint-like pattern including a pattern center of the
41 registered fingerprint-like pattern;

42 said pattern-center determination section including
43 an auxiliary-line generation section for
44 generating two or more auxiliary lines extending
45 continuously from an outer circumference side one of the
46 pattern curves of the fingerprint-like pattern toward an
47 inner circumference side one of the pattern curves so that
48 each of the auxiliary lines intersects each of the pattern
49 curves perpendicularly or substantially perpendicularly,
50 and
51 a pattern-center determination section for
52 determining the pattern center based on one or more
53 intersecting points of the two or more auxiliary lines
54 generated by said auxiliary-line generation section.

1 39. A pattern verification apparatus as claimed in
2 claim 38, wherein
3 said alignment-reference determination section
4 further includes a pattern-orientation determination
5 section for determining a pattern orientation of the
6 fingerprint-like pattern for verification as one of the
7 alignment references,
8 the alignment references of the registered
9 fingerprint-like pattern including a pattern orientation of
10 the registered fingerprint-like pattern, and
11 said pattern-orientation determination section
12 includes
13 a reference-circle generation section for

14 generating a reference circle of a predetermined radius
15 centered at the pattern center determined by said
16 pattern-center determination section,
17 a reference-circle-intersecting-point
18 calculation section for calculating intersecting points of
19 the reference circle generated by said reference-circle
20 generation section and the pattern curves of the registered
21 fingerprint-like pattern,
22 a reference-point determination section for
23 determining a reference point for the pattern orientation
24 based on a relationship between directions of the reference
25 circle and directions of the pattern curves at the
26 intersecting points calculated by said reference-circle-
27 intersecting-point calculation section, and
28 a pattern-orientation determination section for
29 determining the pattern orientation based on the pattern
30 center determined by said pattern-center determination
31 section and the reference point determined by said
32 reference-point determination section.

1 40. A pattern verification apparatus for verifying
2 a group of object minutiae extracted from an object
3 fingerprint-like pattern for verification with a group of
4 registered minutiae extracted in advance from a registered
5 fingerprint-like pattern, each of the object
6 fingerprint-like pattern and the registered fingerprint-
7 like pattern being formed with the number of pattern curves,

8 said apparatus comprising:

9 a pattern inputting section for inputting the object

10 fingerprint-like pattern;

11 an alignment-reference determination section for

12 determining one or more alignment references of the object

13 fingerprint-like pattern inputted by said pattern inputting

14 section;

15 a minutia extraction section for extracting the group

16 of object minutiae from the object fingerprint-like pattern

17 inputted by said pattern inputting section;

18 a registration-data obtaining section for obtaining

19 registration data regarding the registered fingerprint-like

20 pattern, said registration data including the group of

21 registered minutiae and one or more alignment references of

22 the registered fingerprint-like pattern;

23 an alignment section for aligning the object

24 fingerprint-like pattern or the group of object minutiae and

25 the group of registered minutiae so that the alignment

26 references of the object fingerprint-like pattern determined

27 by said alignment-reference determination section and the

28 alignment references of the registered fingerprint-like

29 pattern obtained by said registration-data obtaining section

30 coincide with each other; and

31 a verification section for verifying the group of

32 object minutiae with the group of registered minutiae based

33 on the alignment by said alignment section;

34 said alignment-reference determination section

35 including a pattern-orientation determination section for
36 determining a pattern orientation of the object
37 fingerprint-like pattern as one of the alignment references,
38 the registered alignment references of the registered
39 fingerprint-like pattern including a pattern orientation of
40 the registered fingerprint-like pattern;
41 said pattern-orientation determination section
42 including
43 a pattern-center determination section for
44 determining a pattern center of the object fingerprint-like
45 pattern,
46 a reference-circle generation section for
47 generating a reference circle of a predetermined radius
48 centered at the pattern center of the object fingerprint-like
49 pattern determined by said pattern-center determination
50 section,
51 a reference-circle-intersecting-point
52 calculation section for calculating intersecting points of
53 the reference circle generated by said reference-circle
54 generation section and the pattern curves of the object
55 fingerprint-like pattern,
56 a reference-point determination section for
57 determining a reference point for the pattern orientation
58 based on a relationship between directions of the reference
59 circle and directions of the pattern curves at the
60 intersecting points calculated by said reference-circle-
61 intersecting-point calculation section, and

62 a pattern-orientation determination section for
63 determining the pattern orientation based on the pattern
64 center determined by said pattern-center determination
65 section and the reference point determined by said
66 reference-point determination section.

1 41. A pattern verification apparatus as claimed in
2 claim 38, wherein said pattern inputting section is operable
3 to input the registered fingerprint-like pattern, said
4 alignment-reference determination section is operable to
5 determine the alignment references of the registered
6 fingerprint-like pattern inputted by said pattern inputting
7 section, said minutia extraction section is operable to
8 extract the group of registered minutiae from the registered
9 fingerprint-like pattern inputted by said pattern inputting
10 section, and said registration-data obtaining section is
11 operable to obtain both the alignment references of the
12 registered fingerprint-like pattern determined by said
13 alignment-reference determination section and the group of
14 registered minutiae extracted by said minutia extraction
15 section as the registration data regarding the registered
16 fingerprint-like pattern.

1 42. A pattern verification apparatus as claimed in
2 claim 39, wherein said pattern inputting section is operable
3 to input the registered fingerprint-like pattern, said
4 alignment-reference determination section is operable to

5 determine the alignment references of the registered
6 fingerprint-like pattern inputted by said pattern inputting
7 section, said minutia extraction section is operable to
8 extract the group of registered minutiae from the registered
9 fingerprint-like pattern inputted by said pattern inputting
10 section, and said registration-data obtaining section is
11 operable to obtain both the alignment references of the
12 registered fingerprint-like pattern determined by said
13 alignment-reference determination section and the group of
14 registered minutiae extracted by said minutia extraction
15 section as the registration data regarding the registered
16 fingerprint-like pattern.

1 43. A pattern verification apparatus as claimed in
2 claim 40, wherein said pattern inputting section is operable
3 to input the registered fingerprint-like pattern, said
4 alignment-reference determination section is operable to
5 determine the alignment references of the registered
6 fingerprint-like pattern inputted by said pattern inputting
7 section, said minutia extraction section is operable to
8 extract the group of registered minutiae from the registered
9 fingerprint-like pattern inputted by said pattern inputting
10 section, and said registration-data obtaining section is
11 operable to obtain both the alignment references of the
12 registered fingerprint-like pattern determined by said
13 alignment-reference determination section and the group of
14 registered minutiae extracted by said minutia extraction

15 section as the registration data regarding the registered
16 fingerprint-like pattern.

1 44. A pattern verification apparatus as claimed in
2 claim 38, further comprising:

3 an adjustment-shift calculation section for
4 calculating an adjustment shift of the group of object
5 minutiae or/and the group of registered minutiae based on
6 a result of the verification by said verification section
7 so that the alignment of the group of object minutiae and
8 the group of registered minutiae is improved; and

9 an alignment-result adjustment section for shifting
10 the group of object minutiae or/and the group of registered
11 minutiae by the adjustment shift calculated by said
12 adjustment-shift calculation section so as to adjusting a
13 result of the alignment by said alignment section;

14 said verification section being operable to output a
15 result of the verification between the group of object
16 minutiae and the group of registered minutiae based on the
17 adjustment of the alignment result by said alignment-result
18 adjustment section.

1 45. A pattern verification apparatus as claimed in
2 claim 39, further comprising:

3 an adjustment-shift calculation section for
4 calculating an adjustment shift of the group of object
5 minutiae or/and the group of registered minutiae based on

6 a result of the verification by said verification section
7 so that the alignment of the group of object minutiae and
8 the group of registered minutiae is improved; and
9 an alignment-result adjustment section for shifting
10 the group of object minutiae or/and the group of registered
11 minutiae by the adjustment shift calculated by said
12 adjustment-shift calculation section so as to adjust a result
13 of the alignment by said alignment section;
14 said verification section being operable to output a
15 result of the verification between the group of object
16 minutiae and the group of registered minutiae based on the
17 adjustment of the alignment by said alignment-result
18 adjustment section.

1 46. A pattern verification apparatus as claimed in
2 claim 40, further comprising:

3 an adjustment-shift calculation section for
4 calculating an adjustment shift of the group of object
5 minutiae or/and the group of registered minutiae based on
6 a result of the verification by said verification section
7 so that the alignment of the group of object minutiae and
8 the group of registered minutiae is improved; and

9 an alignment-result adjustment section for shifting
10 the group of object minutiae or/and the group of registered
11 minutiae by the adjustment shift calculated by said
12 adjustment-shift calculation section so as to adjust a result
13 of the alignment by said alignment section;

14 said verification section being operable to output a
15 result of the verification between the group of object
16 minutiae and the group of registered minutiae based on the
17 adjustment of the alignment by said alignment-result
18 adjustment section.

1 47. A pattern verification apparatus as claimed in
2 claim 44, wherein the adjustment shift is at least one of
3 a rotation angle by which at least one of the group of object
4 minutiae and the group of registered minutiae are to be
5 rotated around a predetermined point with respect to the
6 other of the two groups of minutiae and a shift by which at
7 least one of the group of object minutiae and the group of
8 registered minutiae are to be parallelly shifted with respect
9 to the other of the two groups of minutiae.

1 48. A pattern verification apparatus as claimed in
2 claim 45, wherein the adjustment shift is at least one of
3 a rotation angle by which at least one of the group of object
4 minutiae and the group of registered minutiae are to be
5 rotated around a predetermined point with respect to the
6 other of the two groups of minutiae and a shift by which at
7 least one of the group of object minutiae and the group of
8 registered minutiae are to be parallelly shifted with respect
9 to the other of the two groups of minutiae.

1 49. A pattern verification apparatus as claimed in

2 claim 46, wherein the adjustment shift is at least one of
3 a rotation angle by which at least one of the group of object
4 minutiae and the group of registered minutiae are to be
5 rotated around a predetermined point with respect to the
6 other of the two groups of minutiae and a shift by which at
7 least one of the group of object minutiae and the group of
8 registered minutiae are to be parallelly shifted with respect
9 to the other of the two groups of minutiae.

1 50. A pattern alignment apparatus for aligning two
2 fingerprint-like patterns, each of which is formed with a
3 number of pattern curves, while adjusting the alignment of
4 the two fingerprint-like patterns, comprising:

5 an alignment section for aligning the two
6 fingerprint-like patterns;

7 a minutia extraction section for extracting a group
8 of minutiae from each of the fingerprint-like patterns;

9 a collation section for collating the two group of
10 minutiae extracted from the two fingerprint-like patterns
11 by said minutia extraction section based on the alignment
12 by said alignment section;

13 an adjustment-shift calculation section for
14 calculating an adjustment shift by which at least one of the
15 two fingerprint-like patterns is to be shifted for adjusting
16 the alignment of the two fingerprint-like patterns, based
17 on a result of the collation by said collation section so
18 that the alignment of the two fingerprint-like patterns is

19 improved; and
20 an alignment-result adjustment section for shifting
21 at least one of the two fingerprint-like patterns by the
22 adjustment shift calculated by said adjustment-shift
23 calculation section so as to adjust a result of the alignment
24 by said alignment section.

1 51. A pattern alignment apparatus as claimed in
2 claim 50, further comprising
3 a permissible-shift-range calculation section for
4 calculating a permissible shift range, said permissible
5 shift range being a shift range within which, when said
6 collation section has discriminated that one or more minutiae
7 of one of the two fingerprint-like patterns coincide with
8 one or more minutiae of the other of the two fingerprint-like
9 patterns respectively, one of the two fingerprint-like
10 patterns can be shifted with respect to the other of the two
11 fingerprint-like patterns while at least some of the one or
12 more pairs of coinciding minutiae maintain the coincidence
13 relationship,

14 said adjustment-shift calculation section being
15 operable to calculate the adjustment shift within the
16 permissible shift range calculated by said permissible-
17 shift-range calculation section.

1 52. A pattern alignment apparatus as claimed in
2 claim 50, wherein the adjustment shift is at least one of

3 a rotation angle by which one of the two fingerprint-like
4 patterns is to be rotated around a predetermined point with
5 respect to the other of the two fingerprint-like patterns
6 and a shift by which one of the two fingerprint-like patterns
7 is to be parallelly shifted with respect to the other of the
8 two fingerprint-like patterns.

1 53. A pattern alignment apparatus as claimed in
2 claim 51, wherein the adjustment shift is at least one of
3 a rotation angle by which one of the two fingerprint-like
4 patterns is to be rotated around a predetermined point with
5 respect to the other of the two fingerprint-like patterns
6 and a shift by which one of the two fingerprint-like patterns
7 is to be parallelly shifted with respect to the other of the
8 two fingerprint-like patterns.